SF6 and helium data from a tracer release experiment conducted June 2018 in the coastal Baltic Sea during FS Alkor cruise AL510

Website: https://www.bco-dmo.org/dataset/915772
Data Type: Cruise Results, experimental
Version: 1
Version Date: 2024-01-10

Project
» Collaborative Research: Influence of Surfactants on Air-Sea Gas Exchange: 3He/SF6 Experiments in the Baltic Sea (Baltic GasEx)

Programs
» United States Surface Ocean Lower Atmosphere Study (U.S. SOLAS)
» Ocean Carbon and Biogeochemistry (OCB)

Contributors	Affiliation	Role
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Abstract
These data are 3He and SF6 from a tracer release experiment conducted in the coastal Baltic Sea. The experiment was conducted in June 2018 and the goal was to determine gas transfer velocities in the Baltic Sea, where it is thought that excess surfactants and limited wind fetch would affect the relationship between wind speed and gas transfer velocity.

Table of Contents

Coverage

Spatial Extent: **N**:54.7075 **E**:10.1787 **S**:54.5343 **W**:10.0724
Temporal Extent: 2018-06-06 - 2018-06-12

Methods & Sampling

A tracer release experiment was conducted in the coastal Baltic Sea during cruise AL510 aboard the research vessel FS Alkor. On June 4th, 2018, we injected 3He and SF6 into the surface ocean (~5 m depth). After the injection, near the center of the SF6 patch, depth profiles of temperature and salinity were measured using a conductivity, temperature, and depth (CTD) sonde and water samples were collected in Niskin bottles.

Discrete SF6 samples (and replicates) were drawn from the Niskin bottles using 550 ml glass bottles with ground-glass stoppers. For discrete 3He samples, ~40 milliliters of seawater were collected in copper tubes mounted in aluminum channels and sealed at the ends with stainless steel clamps.

SF6 samples were taken at the same stations and measured on board the FS Alkor. Concentration of SF6 was measured using a purge-and-trap SF6 analysis system designed following Law et al. (1994). In this system, SF6 was separated from other gases and measured with a gas chromatography electron capture detector (GC-ECD).

3He samples were measured at the Lamont-Doherty Earth Observatory (LDEO) Noble Gas Laboratory. In the laboratory, 3He samples were extracted from the copper tubes using a vacuum extraction system (Ludin et al., 1998) and measured on a VG-5400 He isotope mass spectrometer. Precision is about 0.5 to 1% in δ3He for samples with high δ3He values (100% < δ3He < 1000%), and 0.2 to 0.5% for samples with lower δ3He values (-1.7% < δ3He < 100%).

Data Processing Description

We calculated 3He excess from the measured 3He/4He ratio and 4He concentration.
3He excess is 3He in excess of solubility equilibrium calculated using the following equation:

[3He]exc = [4He]s (Rs − Ra) + [4He]eqRa(1 − a),

where:

- [3He]exc is 3He in excess of solubility equilibrium
- [4He]s is the measured 4He concentration of the sample;
- [4He]eq is the atmospheric equilibrium concentration of 4He (Weiss, 1971);
- R**s** is the measured 3He/4He ratio (ratio of **s**ample);
- R**a** is the 3He/4He ratio in the **a**tmosphere (1.386×10^{-6} (Clarke et al. 1976));
- From *(1 - a*), a is the solubility isotope effect (0.983 (Benson and Krause, 1980)).

BCO-DMO Processing Description

* Imported data from source file "Baltic_Gas_Ex_1_20231113_with_SF6.txt" into the BCO-DMO data system.
* Modified parameter (column) names to conform with BCO-DMO naming conventions.
* Converted datetime to ISO8601 format yyyy-mm-ddThh:mm:ssZ
* Added column for station based on latitudes and longitudes

[table of contents | back to top]

Data Files

File
915772_v1_sf6_helium.csv (Comma Separated Values (.csv), 4.40 KB) MD5:8f68022b581d2d9cd5f33489250db945 Primary data file for dataset ID 915772, version 1

[table of contents | back to top]

Related Publications

Benson, B. B., & Krause, D. (1980). Isotopic fractionation of helium during solution: A probe for the liquid state. Journal of Solution Chemistry, 9(12), 895–909. https://doi.org/10.1007/bf00646402 https://doi.org/10.1007/BF00646402
Methods

Clarke, W. B., Jenkins, W. J., & Top, Z. (1976). Determination of tritium by mass spectrometric measurement of 3He. The International Journal of Applied Radiation and Isotopes, 27(9), 515–522. https://doi.org/10.1016/0020-708x(76)90082-x https://doi.org/10.1016/0020-708X(76)90082-X
Methods

Ho, D. T., Schlosser, P., & Caplow, T. (2002). Determination of Longitudinal Dispersion Coefficient and Net Advection in the Tidal Hudson River with a Large-Scale, High Resolution SF6 Tracer Release Experiment. Environmental Science & Technology, 36(15), 3234–3241. https://doi.org/10.1021/es015814+
Methods

Law, C. S., Watson, A. J., & Liddicoat, M. I. (1994). Automated vacuum analysis of sulphur hexafluoride in seawater: derivation of the atmospheric trend (1970–1993) and potential as a transient tracer. Marine Chemistry, 48(1), 57–69. https://doi.org/10.1016/0304-4203(94)90062-0
Methods

Ludin, A., Weppernig, R., Boenisch, G., & Schlosser, P. (2017). *Mass Spectrometric Measurement of Helium Isotopes and Tritium in Water Samples* (Version 1.0) [Data set]. Interdisciplinary Earth Data Alliance (IEDA). https://doi.org/10.1594/IEDA/100661
Methods

Weiss, R. F. (1971). Solubility of helium and neon in water and seawater. Journal of Chemical & Engineering Data, 16(2), 235–241. doi:10.1021/je60049a019
General

[table of contents | back to top]

Related Datasets

IsRelatedTo

Schlosser, P., Koffman, T. N. (2024) **Helium isotope and neon data from seawater samples collected June 2018 during FS Alkor cruise AL510 in the Baltic Sea.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-12-05 doi:10.26008/1912/bco-dmo.915490.1 [view at BCO-DMO]

[table of contents | back to top]

Parameters

Parameter	Description	Units
ISO_DateTime_UTC	Date and Time in ISO8601 format in UTC	unitless
Station	Station	unitless
Latitude	Latitude of sampling station	decimal degrees
Longitude	Longitude of sampling station	decimal degrees
Depth	Depth	meters (m)
Temperature	Temperature from CTD sonde	degrees Celsius (°C)
Salinity	Salinity from CTD sonde	PSU
He3_excess	3He excess concentrations calculated from the measured 3He/4He ratio and the 4He concentration	cubic centimeters at standard temperature and pressure per gram times 10^-16 (ccSTP/g*10-16)
SF6_rep1	Sulfur hexafluoride (SF6) concentration	picomoles per kilogram (pmol/kg)
SF6_rep2	Sulfur hexafluoride (SF6) concentration	picomoles per kilogram (pmol/kg)
SF6_rep3	Sulfur hexafluoride (SF6) concentration	picomoles per kilogram (pmol/kg)

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Hydro-Bios MWS-12 CTD sonde
Generic Instrument Name	CTD - profiler
Dataset-specific Description	CTD rosette was used for Niskin sampling
Generic Instrument Description	The Conductivity, Temperature, Depth (CTD) unit is an integrated instrument package designed to measure the conductivity, temperature, and pressure (depth) of the water column. The instrument is lowered via cable through the water column. It permits scientists to observe the physical properties in real-time via a conducting cable, which is typically connected to a CTD to a deck unit and computer on a ship. The CTD is often configured with additional optional sensors including fluorometers, transmissometers and/or radiometers. It is often combined with a Rosette of water sampling bottles (e.g. Niskin, GO-FLO) for collecting discrete water samples during the cast. This term applies to profiling CTDs. For fixed CTDs, see https://www.bco-dmo.org/instrument/869934.

Dataset-specific Instrument Name	GC-ECD (Shimazu GC-14A gas chromatography-electron capture detector)
Generic Instrument Name	Gas Chromatograph
Dataset-specific Description	Gases stripped from seawater were sent to a molecular sieve column, where SF6 was separated from other gases and then measured with a gas chromatography-electron capture detector (Shimazu GC-14A GC-ECD).
Generic Instrument Description	Instrument separating gases, volatile substances, or substances dissolved in a volatile solvent by transporting an inert gas through a column packed with a sorbent to a detector for assay. (from SeaDataNet, BODC)

Dataset-specific Instrument Name	VG-5400 noble gas mass spectrometer
Generic Instrument Name	Mass Spectrometer
Dataset-specific Description	In the laboratory, 3He samples were extracted from the copper tubes and measured on a VG-5400 He isotope mass spectrometer.
Generic Instrument Description	General term for instruments used to measure the mass-to-charge ratio of ions; generally used to find the composition of a sample by generating a mass spectrum representing the masses of sample components.

Dataset-specific Instrument Name	Niskin bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Discrete SF6 samples were drawn from the Niskin bottles using 550 ml glass bottles with ground-glass stoppers.
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

[table of contents | back to top]

Deployments

AL510

Website	https://www.bco-dmo.org/deployment/915500
Platform	FS Alkor
Report	https://oceanrep.geomar.de/id/eprint/46291/1/Cruise_report_AL510_final.pdf
Start Date	2018-06-03
End Date	2018-06-15
Description	Cruise name: Baltic GasEx Chief Scientist Dr. Dennis Booge Departure: 2018-06-03 (Kiel, Germany) Return: 2018-06-15 (Kiel, Germany)

[table of contents | back to top]

Project Information

Collaborative Research: Influence of Surfactants on Air-Sea Gas Exchange: 3He/SF6 Experiments in the Baltic Sea (Baltic GasEx)

Website: https://www.geomar.de/en/research/expeditionen/detail-view/exp/completed/346931/

Coverage: Baltic Sea

NSF Abstract:

Gas exchange, the movement of gases between the atmosphere and the surface ocean (in both directions), is an important process to understand in global biogeochemistry. A particular area of interest is the rate of exchange of gases such as carbon dioxide and dimethyl sulfide, which play important roles in Earth's climate. Understanding and modeling air-sea exchange on a global scale requires understanding of how gas exchange rates vary in response to a number of factors such as temperature, wind speed, and the presence of surface chemical films (known as surfactants) in the ocean. Over the past 25 years, major advances have been made in understanding air-sea gas exchange in the open ocean, mainly due to improvements in methodology and a number of successful process studies. However, some important questions remain, such as what happens near coastal areas (including inland seas), and how surfactants affect gas exchange. The Baltic Sea Gas Exchange Experiment (Baltic GasEx) is a collaboration between scientists from the US and Germany designed to address these questions. Participants in Baltic GasEx will measure the air-sea gas exchange rates with different techniques in the Baltic Sea before and after the spring bloom, when concentrations and compositions of surfactants will be different. The expeditions will be conducted on a German ship (Alkor), with the ultimate goal of quantifying the relationship between wind speed and gas exchange in an inland sea, and understanding the impact of surfactants on air-sea gas exchange. The project will involve significant international collaboration, public education and outreach through both participating U.S. institutions, and substantial student training in partnership with the international collaborators.

NSF funding will support helium-3 and sulfur hexafluoride measurements during Baltic GasEx to determine the gas exchange rate. German colleagues are independently funded to quantify surfactants with AC voltammetry, surface tension, and sum frequency generation; to determine chemical characteristics of the micro layer; and to estimate the gas exchange rate using eddy covariance flux measurements of CO_2 and DMS. The proposed experiment is designed to address the question of whether open ocean wind speed/gas exchange parameterizations can be applied to inland seas like the Baltic. Also, the effect of surfactants on gas exchange has been studied extensively in the laboratory, but there is little direct field evidence for the effect of surfactants on gas exchange. The proposed experiment, with expeditions at times with both high and low surfactant concentrations, should shed new light on the effect of natural surfactants on gas exchange. Finally, some wind speed/gas exchange parameterizations proposed for the Baltic Sea appear to be higher than typical open ocean parameterizations. These are typically based on eddy covariance flux measurements of CO_2. However, in open ocean experiments where both the helium-3/sulfur hexafluoride approach and eddy covariance of CO_2 have been deployed, there seems to be a discrepancy between gas transfer velocities measured with the two techniques. This experiment should show whether a similar difference in gas transfer velocities measured via these two techniques also exists in the Baltic Sea.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using

the Foundation's intellectual merit and broader impacts review criteria.

[table of contents | back to top]

Program Information

United States Surface Ocean Lower Atmosphere Study (U.S. SOLAS)

Website: http://www.us-solas.org/

Coverage: Global

The Surface Ocean Lower Atmosphere Study (SOLAS) program is designed to enable researchers from different disciplines to interact and investigate the multitude of processes and interactions between the coupled ocean and atmosphere.

Oceanographers and atmospheric scientists are working together to improve understanding of the fate, transport, and feedbacks of climate relevant compounds, and also weather and hazards that are affected by processes at the surface ocean.

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Physical, chemical, and biological research near the ocean-atmosphere interface must be performed in synergy to extend our current knowledge to adequately understand and forecast changes on short and long time frames and over local and global spatial scales.

The findings obtained from SOLAS are used to improve knowledge at process scale that will lead to better quantification of fluxes of climate relevant compounds such as CO2, sulfur and nitrogen compounds, hydrocarbons and halocarbons, as well as dust, energy and momentum. This activity facilitates a fundamental understanding to assist the societal needs for climate change, environmental health, weather prediction, and national security.

The US SOLAS program is a component of the International SOLAS program where collaborations are forged with investigators around the world to examine SOLAS issues ubiquitous to the world's oceans and atmosphere.

Â» International SOLAS Web site

Science Implementation Strategy Reports

US-SOLAS (4 MB PDF file)
Other SOLAS reports are available for download from the US SOLAS Web site

Ocean Carbon and Biogeochemistry (OCB)

Website: http://us-ocb.org/

Coverage: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate

Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO2 and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1756807

[table of contents | back to top]